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DEPTH PERCEPTION USING STEREO PANORAMA WITH A SINGLE CAMERA

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Abstract : This study has been undertaken to introduce a novel approach for achieving depth perception in panoramic images using a single camera. While panoramic views can be easily created through various means, generating stereo panoramas for each eye poses significant challenges. Existing methods utilizing rotating pairs of stereo cameras have encountered issues related to parallax and scale changes. To address these challenges, this research proposes Circular Projections, a new family of multiple viewpoint image projections. The system described in this study utilizes circular projections to generate stereo panoramic images from images or videos captured by a single rotating camera. Operating in real-time on a PC, the system enables efficient and seamless generation of stereo panoramas. Importantly, stereo images are created without explicitly computing the 3D structure, relying instead on the viewer's brain to perceive depth effects. Stereo vision traditionally utilizes disparity information between synchronized images captured by stereo cameras to reconstruct the 3D structure of a scene. This involves stereo calibration to estimate camera parameters, stereo correspondence algorithms to find matching pixel pairs, and triangulation to calculate depth values. The obtained depth information is then used to generate a dense point cloud representation of the scene. The implementation of this project involves programming in a suitable computer vision framework and utilizing appropriate libraries for stereo vision processing. Extensive experimentation and evaluation using standard datasets will be conducted to validate the accuracy and efficiency of the proposed algorithm. By employing this innovative approach, the system opens possibilities for enhanced depth perception in panoramic imagery using readily available equipment. The results demonstrate the feasibility and potential applications of the proposed method for capturing and experiencing immersive stereo panoramas. Future work could focus on integrating computational techniques to further refine the depth effects and improve the overall viewing experience.

***IndexTerms* - Autonomous Navigation, Microcontroller board, Sensors, YOLO Algorithm, Point Cloud.**

I. INTRODUCTION

The aim of this project is to identify the trash placed along the street. The project will be able to identify the trash pick the object automatically using stereo vision and perceiving the depth of the object. Once the depth is perceiving the robotic arm will get inputs from the camera to go to the position of the object and pick it up.

Single board computers (SBCs) have emerged as powerful and versatile devices that offer a compact yet capable computing platform. They have gained significant popularity among hobbyists, educators, and professionals alike, enabling a wide range of applications and projects. One such notable SBC is the Raspberry Pi 4, which has become a leading choice for enthusiasts and developers due to its impressive performance, flexibility, and affordability.

The Raspberry Pi camera modules offer a wide range of features and capabilities, making them ideal for various applications in fields such as robotics, home automation, surveillance, computer vision, and more. Their popularity stems from their ease of use, programmability, and seamless integration with the Raspberry Pi ecosystem.

Computer vision is a field of artificial intelligence and computer science that focuses on enabling computers to understand, interpret, and analyze visual data, such as images and videos, similar to how humans perceive and understand the visual world. It involves developing algorithms, models, and techniques to extract meaningful information from visual data and make sense of it.

At first glance, creating panoramic stereoscopic images seems a contradiction. Pictures taken by ordinary cameras, and regular panoramic images, are taken from approximately a single viewpoint. A stereo pair consists of two images taken from two different viewpoints, corresponding to the locations of the two eyes. Two panoramic images, taken from two different viewpoints, can be viewed as a stereo pair in a direction perpendicular to the line connecting the two viewpoints.

II. LITERATURE SURVEY

The paper [1], presents the development of an autonomous ball picking robot. The main objective was to increase the capability of a 6-axis industrial robot. The project was performed to demonstrate the autonomous capability of the robot to deal with a dynamic operational environment. The system developed features like visual processing on two.

cameras by an outside computer. One camera search for objects randomly launched at the robot to determine the location and color, while the other camera is used for digital feedback control of the gripper style end-effector. The project has demonstrated how the outside sensors and processing can control a robot to grip and sort objects by color and location.

In paper [2], a robotic sorting arm based on color recognition technique was demonstrated. The image processing algorithms and Inverse Kinematics algorithm were combined to develop a robotic arm that can sort objects according to their shape and color. The paper also mentioned that performing image processing on Raspberry Pi will reduce the size of the system while increase the efficiency in terms of power consumption also Installing light sensors can reduce the interference from the environment and using more Sophisticated neural network can help the system differentiate a larger variety of the objects.

In paper [3], the team managed to design and implement a robotic arm that has the talent to accomplish simple tasks like light material handling. They designed and built the robot arm from acrylic material where servo motors were used to perform links between arms and execute arm movements.

The design of the robot arm was limited to four degrees of freedom since this design allows most of the necessary movements and keeps the costs and the complexity of the robot competitively.

In paper [4]an object sorting robotic arm based on color sensing was developed. This can be useful to categorize the objects which move on a conveyor belt. The proposed method of categorization is based on the color of the object. In this project the system categorizes balls of three different colors. The detection of the color is done by a light intensity to frequency converter method. The robotic arm is controlled by a microcontroller-based system which controls DC servo motors.

Paper [5] has discussed the process of sorting objects and how they can be done by using autonomous machines that can recognize objects. It presented a system in which a robotic arm sorts of objects according to their color and shape.

Objects are categorized into three colors which are red, blue, and green. The objects are also differentiated based on their shape into two categories, one with edges and other without edges. The image of the object to be sorted is captured using a webcam and image processing is done using MATLAB. The robotic arm was controlled by an ARM 7 based system. Geared DC motors were used for operating the robotic arm.

Paper [6] presents the color-based object sorting system which uses machine vision and the operations in image processing. The main objective was to develop a compact, easy, and accurate objects sorting machine using real time color image processing method to continuously evaluate and inspect the color deformity using camera-based machine vision. The servomotors used in the robot arm play the vital role as control movement of the robot arm wholly depends on control signal given to servo motor. Hence to operate the system accurately the synchronization between IR sensors, dc motors of the conveyor belt and robot arm is very essential.

Paper [7] presented a system in which a robotic arm sorts of objects according to their color and shape. The objects are categorized into three colors which are red, blue, and green. The objects are also differentiated based on their shape into two categories, one with edges and other without edges. The image of the object to be sorted is captured using a webcam and image processing is done using MATLAB. They used the ARM7 based system to control the robotic arm and Geared DC motors were used for operating the robotic arm.

In paper [8], The project led to the development of a new compact soft actuation unit intended to be used in multi degree of freedom and small-scale robotic systems such as the child humanoid robot "iCub". Compared to the other existing series elastic linear or rotary implementations the proposed design shows high integration density and wider passive deflection. The miniaturization of the newly developed high-performance unit was achieved with the use of a new rotary spring module based on a novel arrangement of linear springs. Their control scheme is a velocity-based controller that generates command signals based on the desired simulated stiffness using the spring deflection state.

In paper [9], the project deals with the designing of a Synchronized Robotic Arm, which is used to perform all the basic activities like picking up objects and placing them. They have designed a robotic arm, synchronized it with the working arm which allows it to perform the task as the working arm does. The work done by the robotic arm would be highly precise since they have used a digital servo motor. They have used a servo motor of 230 oz-inch. This robotic arm can also be used for precision work. For instance, some work must be done very precisely but the conditions do not suit human beings. In such conditions, this robotic arm can be used remotely, and the task can be accomplished. The programming is done on ATMEGA-8 Microcontroller using Arduino programming.

III. RESEARCH METHODOLOGY

3.1 Robotic Arm Controller

To control the Robotic Arm an IOT based platform is being used. In this project we have used Blynk, which can connect phones with different microcontrollers. Blynk provides us with a cloud database which would be used to communicate between Blynk app and microcontroller.

In Blynk four buttons have been defined for four different parameters and assign voltage variable to all these four buttons.

3.2 Object Detection and Automatic Sorting

To detect objects, we are using OpenCV library and YOLO algorithm - You Only Look Once, with python. We detect objects using a web camera and then we send 3 different signals for our small objects. The signal are as follows:

The cloud used in this project is Thing Speak Cloud, an open-source cloud platform. ESP8266 is used to communicate the data with Thing Speak cloud.

Response of Robotic Arm on receiving different signals is as follows:

a. On receiving the signal '1' the robotic arm will pick up the object and place it to the right.

b. On receiving the signal '2' the robotic arm will pick up the object and place it to the left.

c. On receiving the signal '0' the robotic arm stops so that it can wait until the next data is received and both the LED's will turn on.

3.3 Stereo Camera

A stereo camera is a type of camera that consists of two camera sensors positioned side-by-side, with a fixed distance between them. The two cameras mimic the way that two human eyes capture different perspectives of the same scene. By analyzing the differences between the two images, a 3D representation of the environment can be created. Used in object detection and tracking in robotics and autonomous vehicles for navigation and obstacle avoidance.

3.4 Stereo Rectification

Stereo rectification is a process used in computer vision and stereo vision systems to transform the images captured by a stereo camera setup into a common rectified coordinate system. The goal of stereo rectification is to simplify the stereo matching process by aligning the epipolar lines in the rectified images, making it easier to find corresponding points between the left and right views. The stereo rectification process involves several steps.

3.4.1 Calibration

First, the stereo camera setup needs to be calibrated. This involves determining the intrinsic parameters (such as focal length and principal point) of each camera and the extrinsic parameters (such as the relative position and orientation) between the cameras. Calibration is typically done using a calibration target, such as a checkerboard pattern, and a calibration algorithm.

3.4.2 Fundamental Matrix Estimation

The fundamental matrix is a mathematical representation of the geometric relationship between the left and right camera views. It describes the epipolar geometry, which defines the epipolar lines in one image corresponding to points in the other image. The fundamental matrix can be estimated using point correspondences between the two views.

3.4.3 Rectification transformation

Once the fundamental matrix is estimated, the rectification transformation can be computed. The rectification transformation maps the original camera images to a common rectified coordinate system, where the epipolar lines become horizontal and aligned across the images. This transformation is determined based on the camera calibration parameters and the fundamental matrix.

3.4.4 Image Warping

The rectification transformation is applied to the original camera images using a process called image warping. Each pixel in the original images is transformed to its corresponding location in the rectified images. The rectified images are typically created by warping the original images so that corresponding epipolar lines become horizontal.

After stereo rectification, the rectified images can be used for stereo matching algorithms, which involve finding corresponding points or features between the left and right views. Since the epipolar lines are aligned and parallel in the rectified images, the search for correspondences can be simplified, leading to more accurate and efficient stereo matching.

Stereo rectification is an essential step in stereo vision applications, such as depth estimation, 3D reconstruction, and object detection, where precise correspondence matching between stereo image pairs is crucial.

3.5 Using Single Camera for Stereo Feed

Stereo vision, which relies on the depth perception achieved by utilizing the disparity between two camera views, is a powerful technique for various computer vision applications. Traditionally, stereo vision requires the use of two cameras positioned side by side. However, it is possible to simulate stereo vision using a single camera by employing a technique called lateral shifting. This report explores how lateral shifting can be utilized to generate a stereo feed using a single camera. Lateral shifting involves physically shifting the position of a camera laterally or horizontally to capture multiple images of a scene from slightly different viewpoints. These shifted images can then be used to simulate the stereo effect and extract depth information.

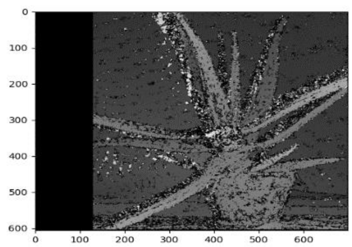
3.5 Using Yolo Algorithm for Object Recognition

Object recognition is a fundamental task in computer vision that involves identifying and locating objects within digital images or video frames. Over the years, various algorithms and techniques have been developed to improve the accuracy and efficiency of object recognition. One such prominent algorithm is You Only Look Once (YOLO), which revolutionized real-time object detection and recognition.

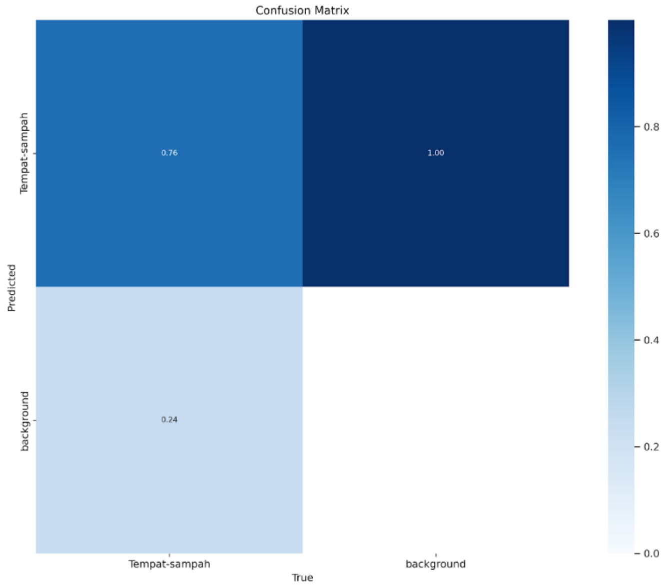
The YOLO algorithm is an object detection system that addresses the object recognition problem in a unified manner. Unlike traditional methods that utilize region proposal techniques, YOLO frames object detection as a regression problem to directly predict bounding boxes and class probabilities within a single forward pass of a convolutional neural network (CNN).

IV. SIMULATION RESULTS

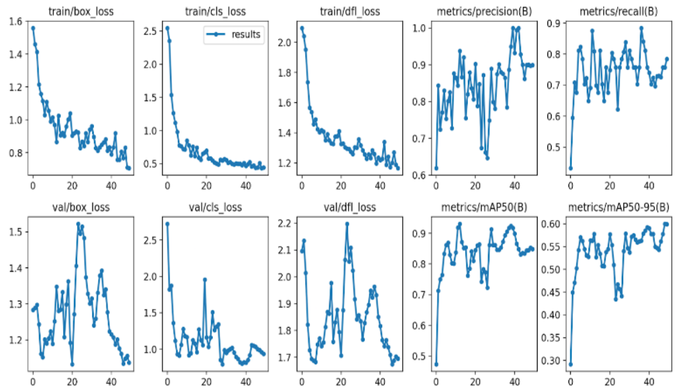
Images Clicked from two different position



Disparity Map Generated



Output of YOLO Algorithm



Visual Representation of our Algorithm Performance

IV. CONCLUSION

In conclusion, this report has explored the concept of using a single camera for stereo feed, aiming to achieve depth perception and simulate the three-dimensional experience typically obtained with stereo cameras. Through the examination of various methodologies, advancements, and challenges, we have gained insights into the potential of this approach and its applications in diverse fields. The use of a single camera for stereo feed offers several advantages, including reduced cost, compactness, and simplified setup. By leveraging innovative computer vision techniques, depth estimation algorithms, and calibration methods, researchers and developers have made significant progress in simulating stereo vision using a single camera. Throughout this report, we have highlighted the key considerations when employing a single camera for stereo feed. These considerations include depth estimation techniques, calibration and synchronization, inherent limitations, and challenges, as well as the applications and benefits of this approach. It is important to recognize that using a single camera for stereo feed presents certain limitations and challenges. Occlusion ambiguity, depth estimation accuracy, and the inability to capture disparities directly are among the challenges that need to be addressed. Ongoing research and development efforts are aimed at overcoming these challenges and improving the performance and accuracy of depth estimation from a single camera feed. In conclusion, the exploration of using a single camera for stereo feed has demonstrated the potential for achieving depth perception and simulating stereo vision. The advancements in computer vision techniques, calibration methods, and depth estimation algorithms have paved the way for innovative applications and solutions in various fields.

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